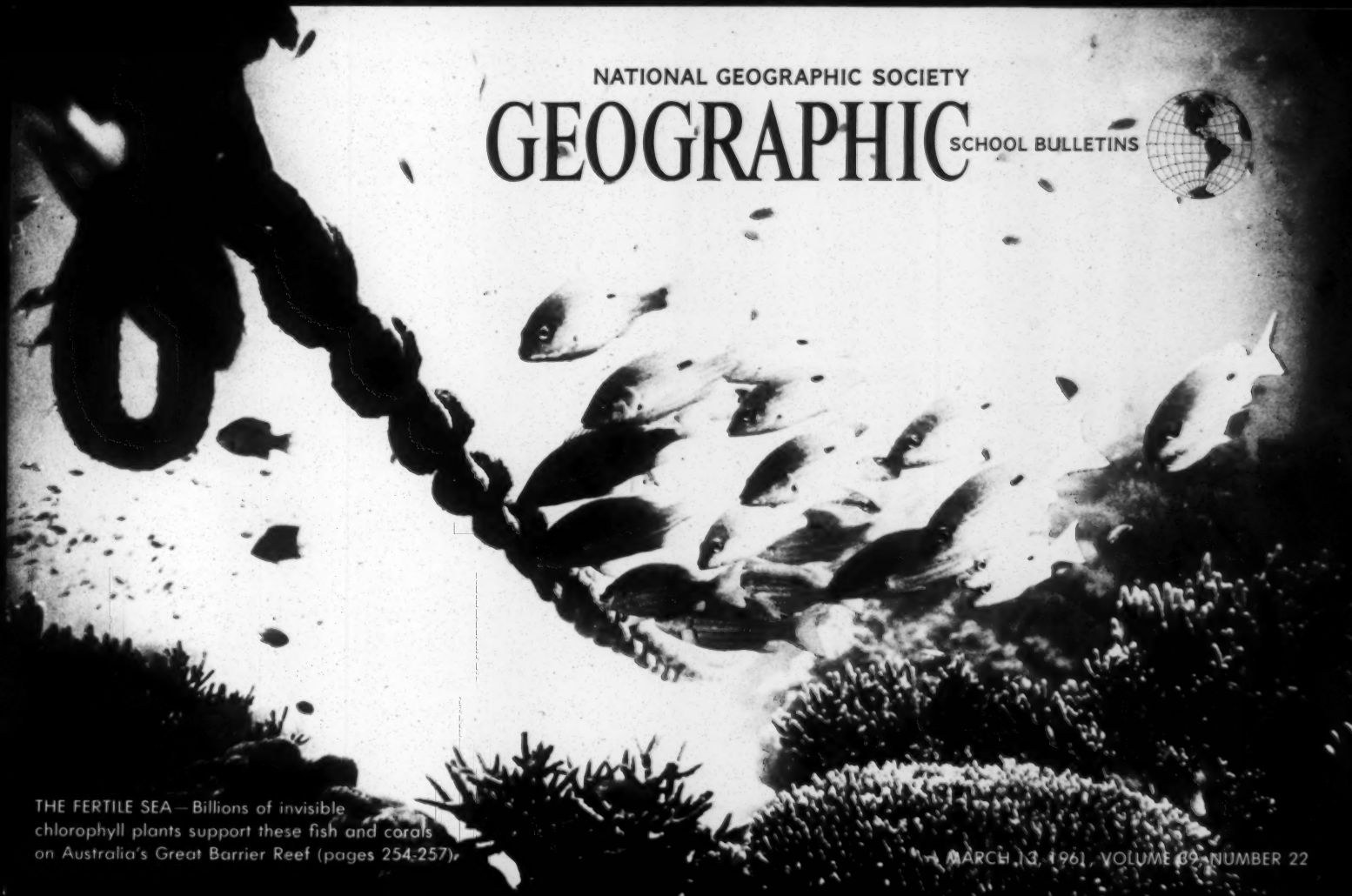
NATIONAL GEOGRAPHIC SOCIETY

GEOGRAPHIC SCHOOL BULLETINS



THE FERTILE SEA—Billions of invisible chlorophyll plants support these fish and corals on Australia's Great Barrier Reef (pages 254-257).

MARCH 13, 1961, VOLUME 39, NUMBER 22

ery of Life on Earth: PHOTOSYNTHESIS

in lacy skeletons like the wheel-shaped specimen below, magnified 300 times life size.

Each diatom is a single-celled organism. It is, in evolution's scale, primitive. Yet inside it happens something that man, the great engineer and chemist, cannot duplicate: photosynthesis.

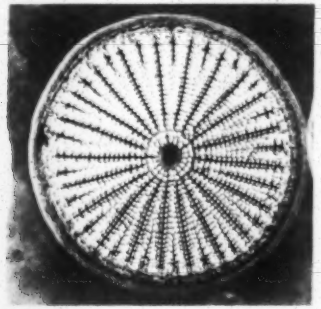
We know what happens in photosynthesis, though we don't know for sure how. Science is struggling to unlock the secrets.

Within the diatom—as within any green plant, on sea or land—is the substance called chlorophyll. This green matter, when struck by the bits of energy that make up a ray of sunlight, is able to switch around the "atomic bricks" that make up molecules.

By this switching, food and oxygen are produced for men and other animals to eat and breathe.

Three things occur in this most important chemical reaction on Earth. First, simple molecules of water and carbon dioxide are transformed into bigger molecules of starch or sugar, called carbohydrates.

Somehow, some of the sun's energy is stored in these new molecules. (This is the energy that powers all of Earth's living machines, including men, and many nonliving machines—whatever runs on coal, petroleum, or natural gas.)



In the third result of photosynthesis, pure oxygen is freed for men and animals to breathe. Though chlorophyll is essential to these changes, this magical substance itself is unchanged by them. It is ready to trigger the process again and again.

IN THIS ISSUE —

- ► Photosynthesis
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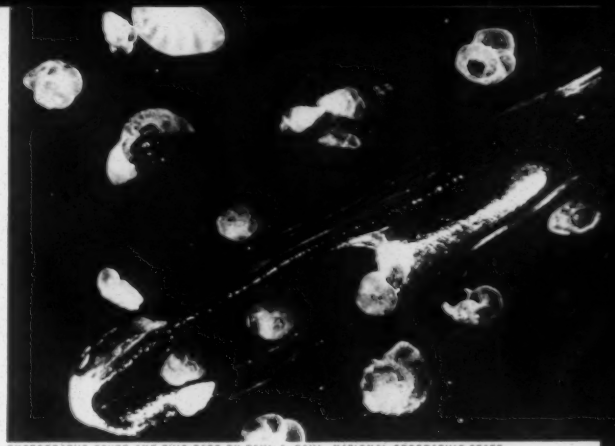
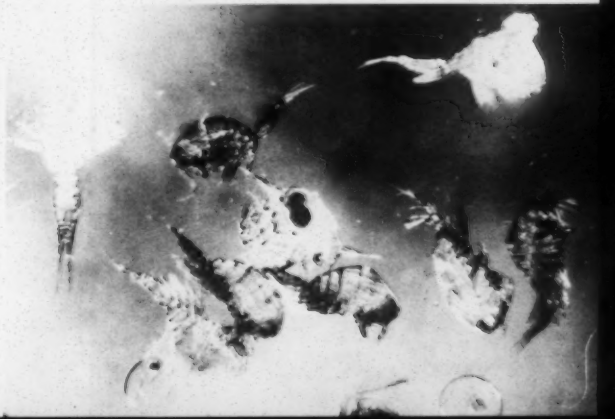


PHOTOGRAPHS COVER AND THIS PAGE BY PAUL A. ZAHL, NATIONAL GEOGRAPHIC STAFF

Specks of sea life pass through a needle's eye. Above, magnified 35 times, are foraminifera, whose calcium shells resemble those of the much larger mollusks. Below, copepods, 30 times life size.



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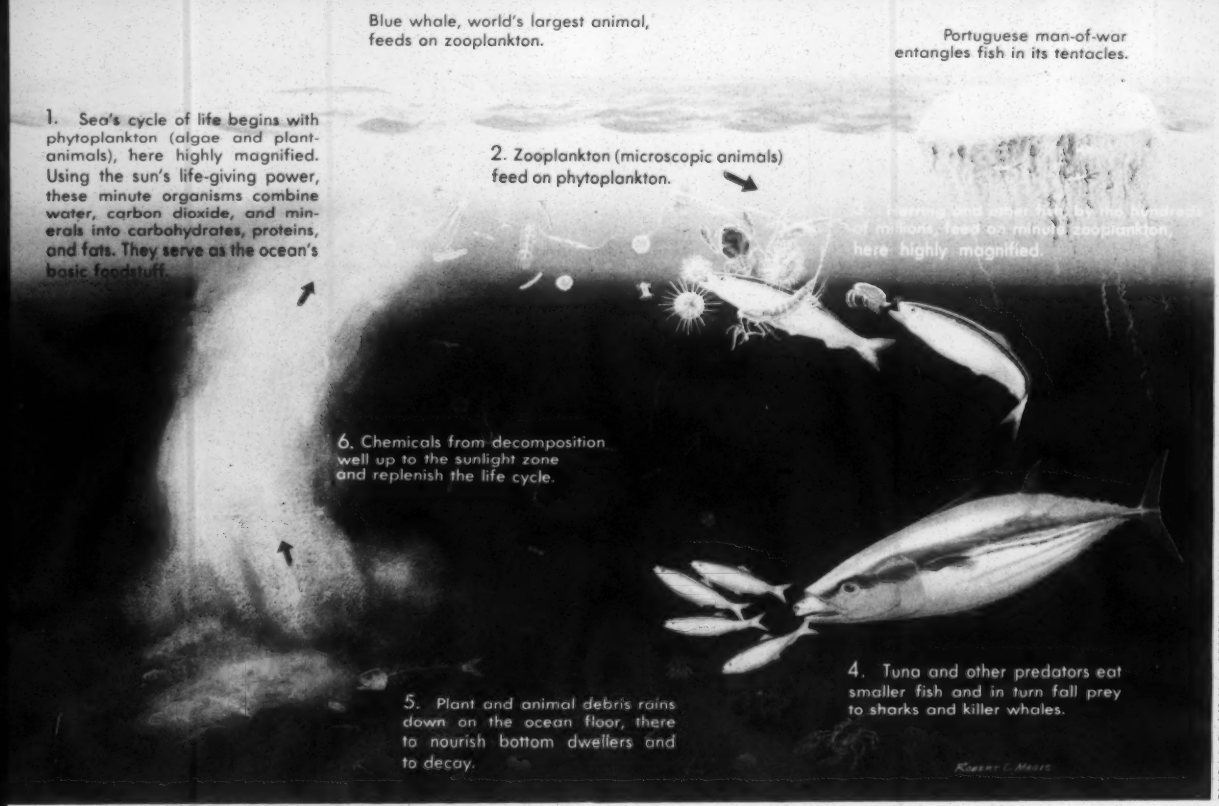
Blue whale, world's largest animal, feeds on zooplankton.
Portuguese man-of-war entangles fish in its tentacles.
1. Sea's cycle of life begins with phytoplankton (algae and plant-animals), here highly magnified. Using the sun's life-giving power, these minute organisms combine water, carbon dioxide, and minerals into carbohydrates, proteins, and fats. They serve as the ocean's basic foodstuff.
2. Zooplankton (microscopic animals) feed on phytoplankton.
3. Herring and other fish, in great schools of millions, feed on minute zooplankton, here highly magnified.
6. Chemicals from decomposition well up to the sunlight zone and replenish the life cycle.
4. Tuna and other predators eat smaller fish and in turn fall prey to sharks and killer whales.
5. Plant and animal debris rains down on the ocean floor, there to nourish bottom dwellers and to decay.

PAINTING BY NATIONAL GEOGRAPHIC STAFF ARTIST ROBERT C. MAGIS

The Mystery

OCEANS HAVE "grass" and "cattle" as does the land.

Bits of life much too small to be seen form the hub of the sea's ever-revolving wheel of life (see drawing, left).

The "grass" of the sea is not seaweed, although that is useful too. More vital is the work of innumerable plants and plant-animals so small that a cubic inch can hold 50 million of them.

These living bits perform life's basic miracle — making food from water and gas.

If man ever learns to imitate this process he could revolutionize life on Earth and, eventually, throughout the solar system.

Among the most important of these "grasses" are the diatoms. They are tiny blobs of life encased

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PAUL A. ZAHL, NATIONAL GEOGRAPHIC STAFF

Harnessing this vast fertility—farming the sea—is a long-held dream. A few tentative steps in this direction have been taken with oysters and mussels, which remain stationary once planted.

Scientists studying water life, such as those netting specimens in the Gulf Stream off the Biminis, left, are also preparing for space exploration.

Since a space ship will have to carry an imitation of Earth's atmosphere, some way of converting the explorers' exhaled carbon dioxide into rebreathable oxygen must go along. A water plant such as the alga Chlorella, it is thought, could do this, and provide food as well. Manned probes of the planets might carry miniature farms.

Even greater marvels will come about if man learns how to reproduce the action of photosynthesis (from the Greek *photo* meaning light, and *synthesis,* putting together).

Writing in the February 1961 *National Geographic,* Paul A. Zahl, staff naturalist, points out:

"There will be a revolution in agriculture, with food for the multitudes made abundantly out of simple carbon dioxide, water, and minerals.

"There will be factories in the desert, reaching out into the air to take power directly from the sun, with no more need for sun-created coal, natural gas, or petroleum. And there will be a way to people airless planets as far away as sunlight can reach." F.S.

• In the issue of March 27, 1961, the *Geographic School Bulletins* will publish an article on algae and their possible uses on Earth and in space.

NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS J. ABERCROMBIE

Base of life—This model of a chlorophyll molecule is displayed by Prof. Robert Burns Woodward in his Harvard laboratory. A group under his direction has built chlorophyll from laboratory chemicals, a triumph that may someday enable man to imitate the process which makes all food on Earth. In the center of the complex linkage is an atom of magnesium. Four nitrogen atoms surround it. The black atoms are carbon, totaling 55. Seventy-two hydrogen atoms (white) and five oxygen atoms complete the total of 137.

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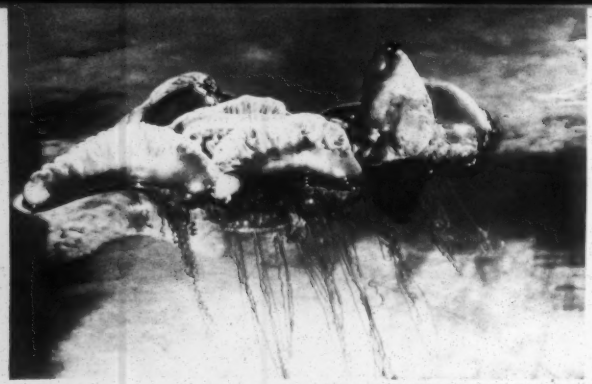


PAUL A. ZAHL, NATIONAL GEOGRAPHIC STAFF

Seagoing predators—Portuguese men-of-war (above) trap small fish in dangling tentacles. The larval crabs below, six times life size, feed on smaller bits of plankton.

Stated in its simplest, photosynthesis shifts the building blocks of nature in this way:

WATER (Hydrogen, Hydrogen, Oxygen) *plus* CARBON DIOXIDE (Carbon, Oxygen, Oxygen) *become* CARBOHYDRATES (Carbon, Hydrogen, Hydrogen, Oxygen) *plus* (Oxygen, Oxygen)

When this process has taken place, a second may occur to complete nature's most basic cycle. An animal eats the plant and breathes the oxygen. The carbohydrates break down, releasing their stored energy, and reverting to water and carbon dioxide. The bricks are reshifted:

CARBOHYDRATES (Carbon, Hydrogen, Hydrogen, Oxygen) *plus* (Oxygen, Oxygen) *become* CARBON DIOXIDE (Carbon, Oxygen, Oxygen) *plus* WATER (Hydrogen, Hydrogen, Oxygen)

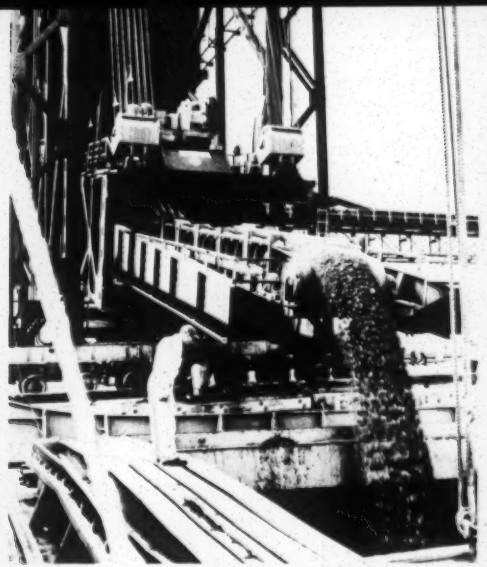
Of course, it is not all this simple; many other elements enter the picture; but this is the vital pair of equations in the cycle of life.

In the sea, the cycle starts with the diatoms, and similar "grasses" which make up in numbers what they lack in size. Diatoms multiply by dividing; each one simply splits in two. In a single month, one diatom, undisturbed, could have 100 million descendants.

The "cattle" that graze off the surplus diatoms are tiny animals. Most prominent in the herd are the copepods, (picture, page 255) flea-sized creatures that may outnumber the total of all the other animals with more than one cell.

A copepod can eat 120,000 diatoms in a day. In the belly of a single herring 60,000 copepods have been found. Uncountable herring disappear into the jaws of larger fish. For human consumption, some 500 million herring are landed in British ports alone each year. The total number of individuals of the smaller inhabitants of the sea is beyond understanding.

Scientists estimate that perhaps two-thirds of Earth's photosynthesis takes place in the oceans. All the grasses, bushes, and trees on land produce an estimated 40 billion tons of carbohydrates in a year; the plants of the sea produce between 80 and 160 billion tons.



UNITED STATES STEEL CORPORATION

A quarter-century ago, Guarauno Indians harvested rubber, tonka beans, fish, giant turtles, and chicle along the Orinoco and its tributaries. Tarantulas, deadly snakes, and vicious red ants thrived.

Lying south and east of the Orinoco River and covering more than half of Venezuela, the Guiana is a land of green savannas rolling from the Orinoco into almost impenetrable jungle. Beyond rise mountains whose legends of gold lured Sir Walter Raleigh in 1595.

The English adventurer never found gold, but today's geologists discover other mineral wealth. The jungle is broken for modern miners' settlements such as El Pao, bottom left. Men who had never seen railroad tracks now drive trains full of El Pao ore to dump at Palua on the Orinoco (below).

In this region lies more iron ore than Minnesota's Mesabi Range produced in half a century. Also surveyed are rich deposits of bauxite, manganese, coal, diamonds, oil, and gas.

At the meeting of the Orinoco and Caroní, Venezuela has built a hydroelectric plant to feed power not only to its own steel plant, which will begin operations this year, but to new industries it hopes to attract. Already providing 200,000 kilowatts, the power plant can produce more if needed.

The Orinoco River has been dredged for 170 miles from its mouth to provide shipping lanes for ocean-going vessels. Planners are designing a model city to hold the 200,000 people expected to flock to the booming area. L.B.

BETHLEHEM STEEL COMPANY

Cerro Bolívar Ore Sparks Venezuelan 'Ruhr'

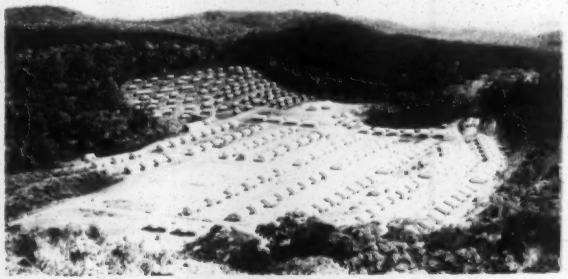
UNITED STATES STEEL CORPORATION

TWENTY-FIVE YEARS AGO, the world knew as much about Venezuela's Guiana region as it did about the hidden side of the moon. Today, roads streak a mountain of iron ore at Cerro Bolívar. Trucks rumble around its hairpin curves, carrying away the mountain load by load.

Railroaded to Puerto Ordaz, at the junction of the Caroní and Orinoco Rivers, the ore cascades (right) into ships that carry it to hungry blast furnaces in the United States.

Soon, Venezuela hopes, the ore will stay at home. Combined with ready electric power, it will produce a "Ruhr of South America," as iron ore and coal joined to build Europe's Ruhr. Finished steel will be shipped from the steaming jungle.

BETHLEHEM STEEL COMPANY



The Ruhr's success is due to location. That great highway of trade, the Rhine, flows along the area's western edge, and the Ruhr, Lippe, and Emscher Rivers drain it as they spill westward into the Rhine.

The network of canals that supplements these waterways connects with all northern Europe. The nearly 300-mile-long Mittelland Kanal, shown below as it passes through Hannover, links the Ruhr with Magdeburg on the Elbe River.

The Ruhr is the steel buckle of the industrial belt girding northern France, Belgium, Luxembourg, and Germany. This belt is underlaid at places with coal waiting to be fanned into productive flame.

The biggest of these deposits lies in the Ruhr region. Coal was shipped from Dortmund as early as 1248, but shaft mining began only in 1837, near Essen, marking the start of the modern Ruhr.

The tremendous supply of fuel fed steel mill after steel mill which rose in the area between 1850 and 1870. Though the local iron mines were soon exhausted, the Ruhr continued in business by importing iron from Sweden, France, Spain, North Africa—a practice continued today.

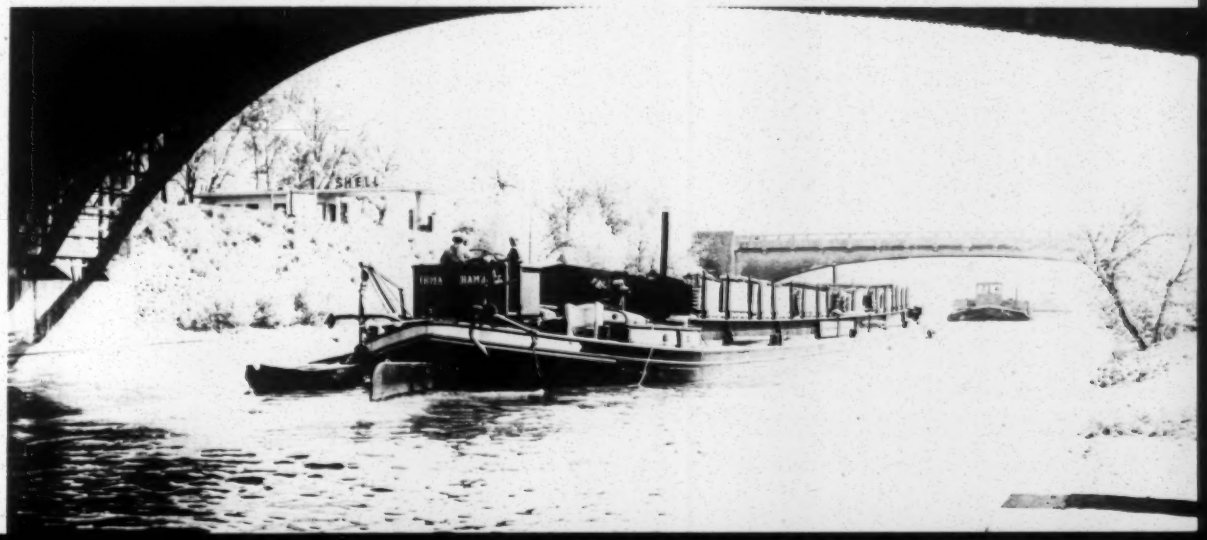
Here was the arsenal with which two German rulers, the Kaiser and Hitler, could wage two world wars in two generations.

World War II bombs reduced the area to a rubble-choked silence. Sixteen years ago the sun shone on the Ruhr, but no one smiled. The smokestacks had cooled; only the shells of factories remained.

Down but not out, the Ruhr flexed its scarred muscles and came back. Today, miners like those at left, in Essen, dig some 125,000,000 tons of coal a year. Blast furnaces turn out 26,000,000 tons of steel every year—more than they did at the height of World War II production. Factories shape all manner and sizes of hard goods.

Other industries have moved in. Both textiles and chemicals are an important part of the Ruhr scene today.

However, the rising competition of oil poses a threat to Ruhr coal. The government has set up an Industrial Development Corporation to improve water supplies, investigate housing needs, extend roads, and expand electric power, all with an eye to attracting new industries to keep the sun from shining on the Ruhr. L.B.



Ruhr Coal Fuels German Powerhouse

WHAT THE VENEZUELANS are working toward in Guiana is a region like Germany's Ruhr, the steelmaking powerhouse not only of West Germany but of all Europe.

Set in a countryside of rolling grass-green hills and woods of fir and beech, the Ruhr throbs with industrial might.

Amid pastoral serenity rise the soot and clangor of chimneys, cooling towers, and blast furnaces. Railroad tracks and barge-laden canals crisscross the area. Coal

PHOTOGRAPHS FROM GERMAN INFORMATION CENTER

mines, like the one at left at Gladbeck, fuel the entire complex. Steel from Ruhr mills is worked into hundreds of products—from giant cranes to table knives.

It has been said that the sun never shines on the Ruhr—the smoke of factories puts a pall between sun and earth.

The Ruhr is not a political area but takes its name from the Ruhr River, a tributary of the Rhine. The region covers some 1,800 square miles—roughly from the Lippe River in the north to Solingen in the south, from the Rhine on the west to the city of Hamm on the east. But into this crowded region smaller than Delaware are packed between 5½ and 6 million people—more than 12 times Delaware's population.

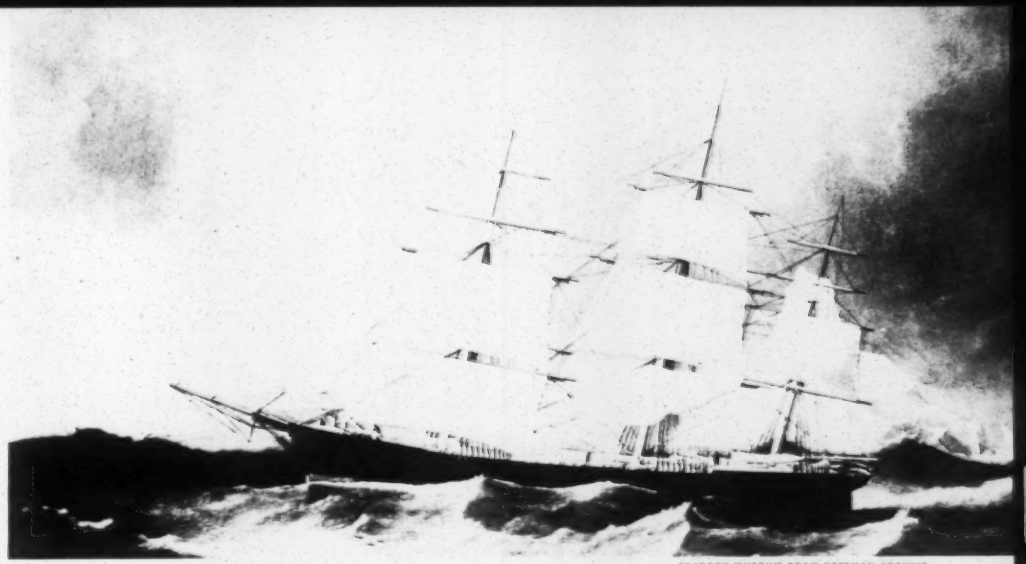
matched by the idealism of transcendental thinkers. Led by Ralph Waldo Emerson, these philosophers believed that God had given man the power to transcend his environment and his times.

This was the age of reform crusades, religious revival, utopian experiments in community living, and a temperance movement so strong that its battle—unlike slavery's—was won without a war. Consumption declined as more people seemed concerned with drink than slavery.

Leaving its "brute youth" behind, the nation developed its own literature for the first time. The original wilderness was at bay, leisure—at least in some quarters—was no longer regarded as a sin, and culture could thrive. Emerson, Henry David Thoreau, Nathaniel Hawthorne, Herman Melville, Walt Whitman, and others were producing classics. New-found wealth and ease made possible the beauty and elegance of Southern planters' homes, and the glorification of social graces and domestic arts. The average Southerner was healthier than his Northern counterpart.

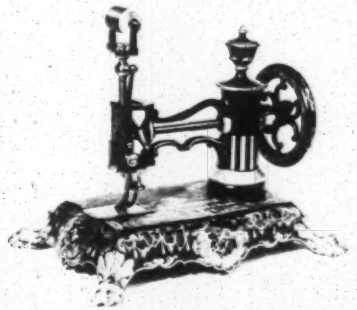
Trade flourished as New Englanders gave up trying to farm rocks and turned to the sea in clipper ships like the *Flying Cloud,* above. The United States had by far the largest merchant marine in the world.

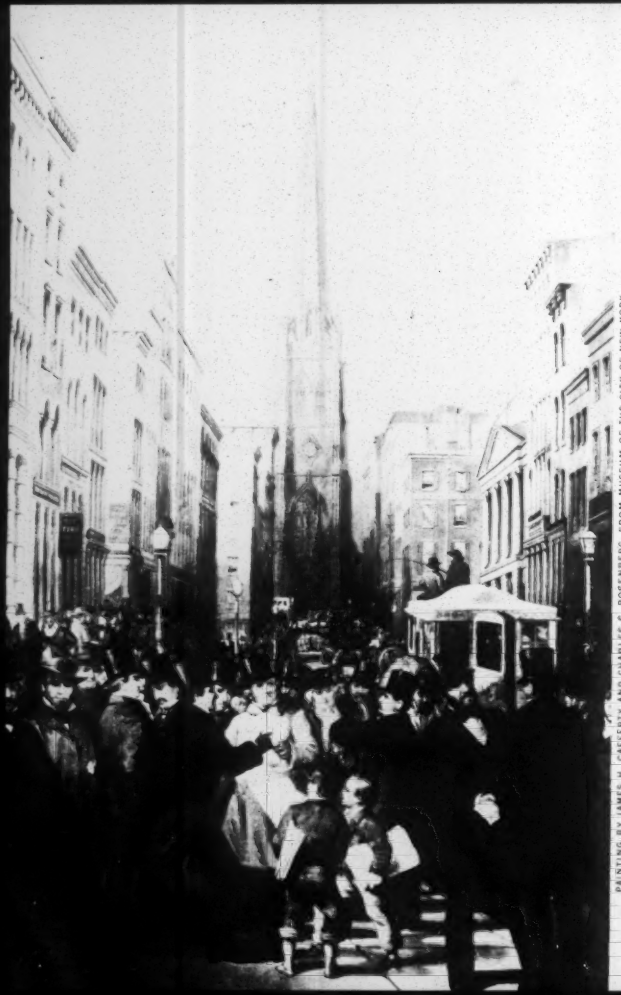
The South produced seven of every eight bales of cotton in the world in 1859. Bales stacked on the docks at New Orleans,



PEABODY MUSEUM FROM BETTMAN ARCHIVE

SMITHSONIAN INSTITUTION, BELOW, AND RIGHT





PAINTING BY JAMES H. CAFFERTY AND CHARLES G. ROSENBERG, FROM MUSEUM OF THE CITY OF NEW YORK

U.S.—1860

Peaceful, Productive "Lull"
Before the Storm of Civil War

BARE HISTORICAL ACCOUNTS of the events leading to the Civil War give the impression that the political issues of the day demanded everyone's complete attention and that the "country stood still," in a sort of breathless vacuum, until the shooting started.

Actually, the nation was moving through its greatest decade of progress and prosperity—an era of peaceful advance symbolized by the telegraph key, above.

Technical innovation and manufacturing, synonymous with America today, were reaching their first flowering in 1850-60, bringing wealth to cities, inspiring increased immigration, and laying early foundations for great fortunes, the industrial age, and the population boom. Railroad empires spread.

A minor recession (1857) in an otherwise prosperous decade sounds as modern as today. The painting at left shows the mild panic on New York City's Wall Street—the financial heart of the country then as now.

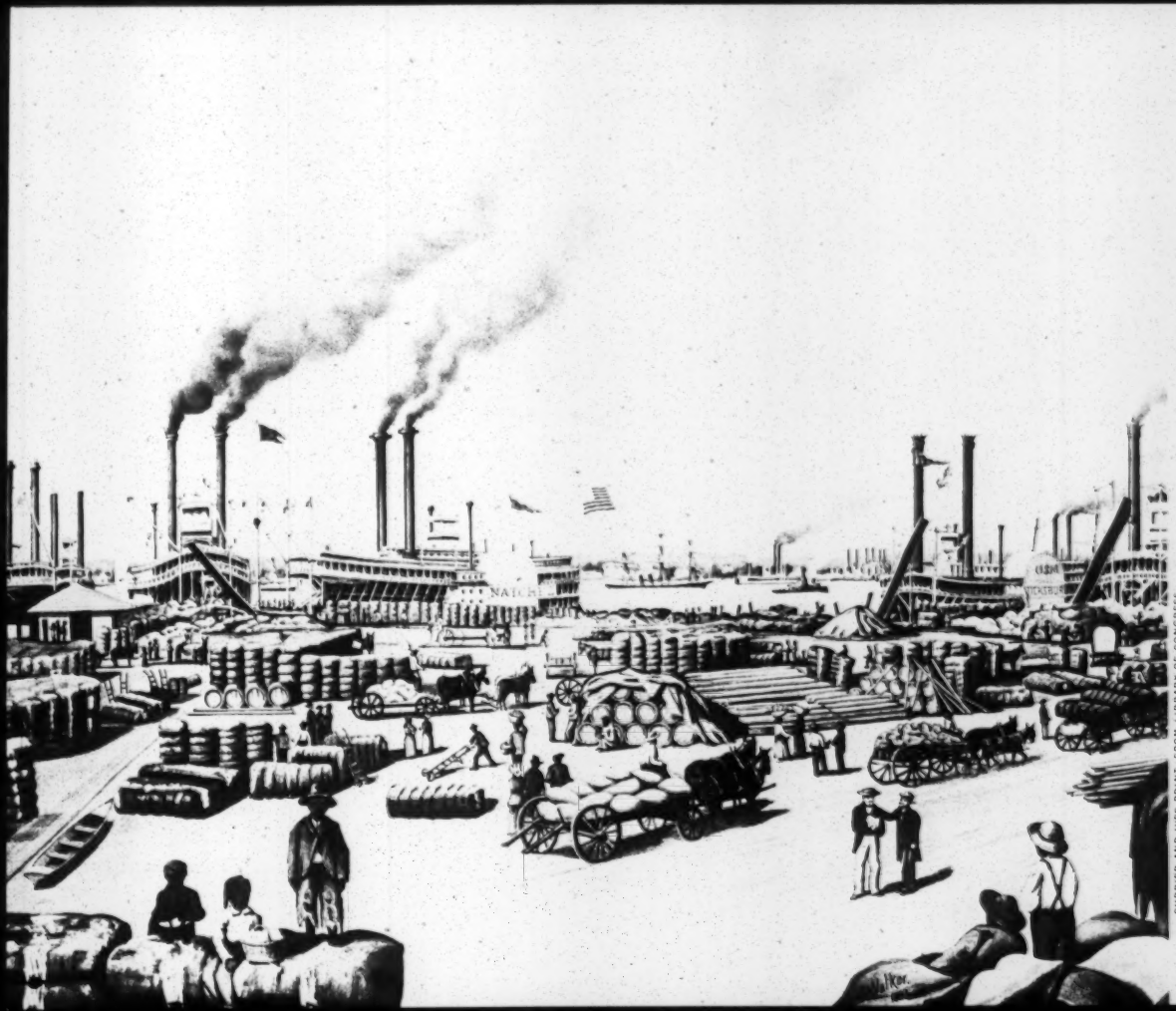
A New York hotel installed the first passenger elevator. A revolutionary marvel, home electric lighting, was successfully demonstrated. The New York and Erie Railroad put sleeping cars into service. The first repeating rifle appeared, prototype of the improved Winchester, lower right. The first trans-Atlantic cable was laid. The Pony Express braved Indians to speed mail to the West Coast.

Congress established the Government Printing Office, which was to become the largest printing establishment in the world. The Land Grant College idea was born—offering higher education in arts and science to everyone.

Far from being dominated by the right or wrong of slavery, the thoughts of men were occupied by such things as crops and weather. They pondered a new literature, moral reforms, state aid to education, and the cost of haircuts (12 cents).

Women, North and South, were welcoming a new type of steel hoop that lightened the burden of their floor-sweeping skirts. Improvements in the sewing machine (right) were emancipating housewives from the thimble.

The craze of phrenology—reading character by feeling bumps on the head—was



CURRIER AND IVES PRINT. FROM LIBRARY OF CONGRESS

Louisiana (left), Charleston, South Carolina, and other ports were the white gold of the Confederacy. Slavery was the machinery for planting, picking, and shiploading it.

Northern farmers turned to such new mechanical aids as the reaper to bring in their diversified crops.

To avoid competition with slaves, nearly all immigrants settled in the North. Of the entire United States 1860 population of 31,000,000 over 4,000,000 were recent immigrants attracted by America's prosperity and unusual personal liberty. Knowing nothing of state's rights, but only of the United States—their "star of hope in the western sky"—they became ardent Unionists when the war began.

The South held 9,000,000 persons, one third of them slaves; thus for every 20 whites in the North there were only six in the Confederacy. R. G.

UMI